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Unsupervised Lung Segmentation for Radiomics Studies: Preliminary Results

Alessandro Stefano
Ingegnere Informatico

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(2 Ing. Informatici, 1 Fisico, 3 Biologi)






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1 Coll.re Tecnico (Biologo)

Età Media: 40 Anni

1 Associato (Informatico)

1 Assegnista (Biologo)

Laboratori:

- di Fisica Medica ed Elaborazione di Bioimmagini (G. Russo)
- di Metodologie Genomiche e Cellulari (G. Forte)

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STUDIORUM UNIVERSITAS MESSANAE

Choline PET/CT features to predict survival outcome in high risk prostate cancer restaging: a preliminary machine-learning radiomics study.

Alongi P[1], Laudicella R[2], Stefano A[3], Caobelli F[4], Comelli A[5], Vento A[6], Sardina D[7], Ganduscio G[7], Toia P[8], Ceci F[9], Mapelli P[10], Picchio M[10], Midiri M[8], Baldari S[6], Lagalla R[8], Russo G[3]

Author information ▸

The Quarterly Journal of Nuclear Medicine and Molecular Imaging : Official Publication of the Italian Association of Nuclear Medicine (AIMN) [and] the International Association of Radiopharmacology (IAR), [and] Section of the Society of.., 15 Jun 2020,

DOI: 10.23736/s1824-4785.20.03227-6 PMID: 32543166

Fondazione Istituto G. Giglio di Cefalù

Computers in Biology and Medicine 120 (2020) 103701

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Computers in Biology and Medicine

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Development of a new fully three-dimensional methodology for tumours delineation in functional images

Albert Comelli[a], Samuel Bignardi[b], Alessandro Stefano[c,*], Giorgio Russo[c,d], Maria Gabriella Sabini[d], Massimo Ippolito[e], Anthony Yezzi[b]

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OSPEDALE CANNIZZARO CATANIA
AZIENDA OSPEDALIERA PER L'EMERGENZA

AZIENDA OSPEDALIERO-UNIVERSITARIA POLICLINICO-VITTORIO EMANUELE

diagnostics MDPI

Article

Performance of Radiomics Features in the Quantification of Idiopathic Pulmonary Fibrosis from HRCT

Alessandro Stefano[1], Mauro Gioè[2], Giorgio Russo[1*], Stefano Palmucci[3], Sebastiano Emanuele Torrisi[4], Samuel Bignardi[5], Antonio Basile[3], Albert Comelli[6,1], Viviana Benfante[1], Gianluca Sambataro[3,7], Daniele Falsaperla[3], Alfredo Gaetano Torcitto[3], Massimo Attanasio[2], Anthony Yezzi[5] and Carlo Vancheri[4]

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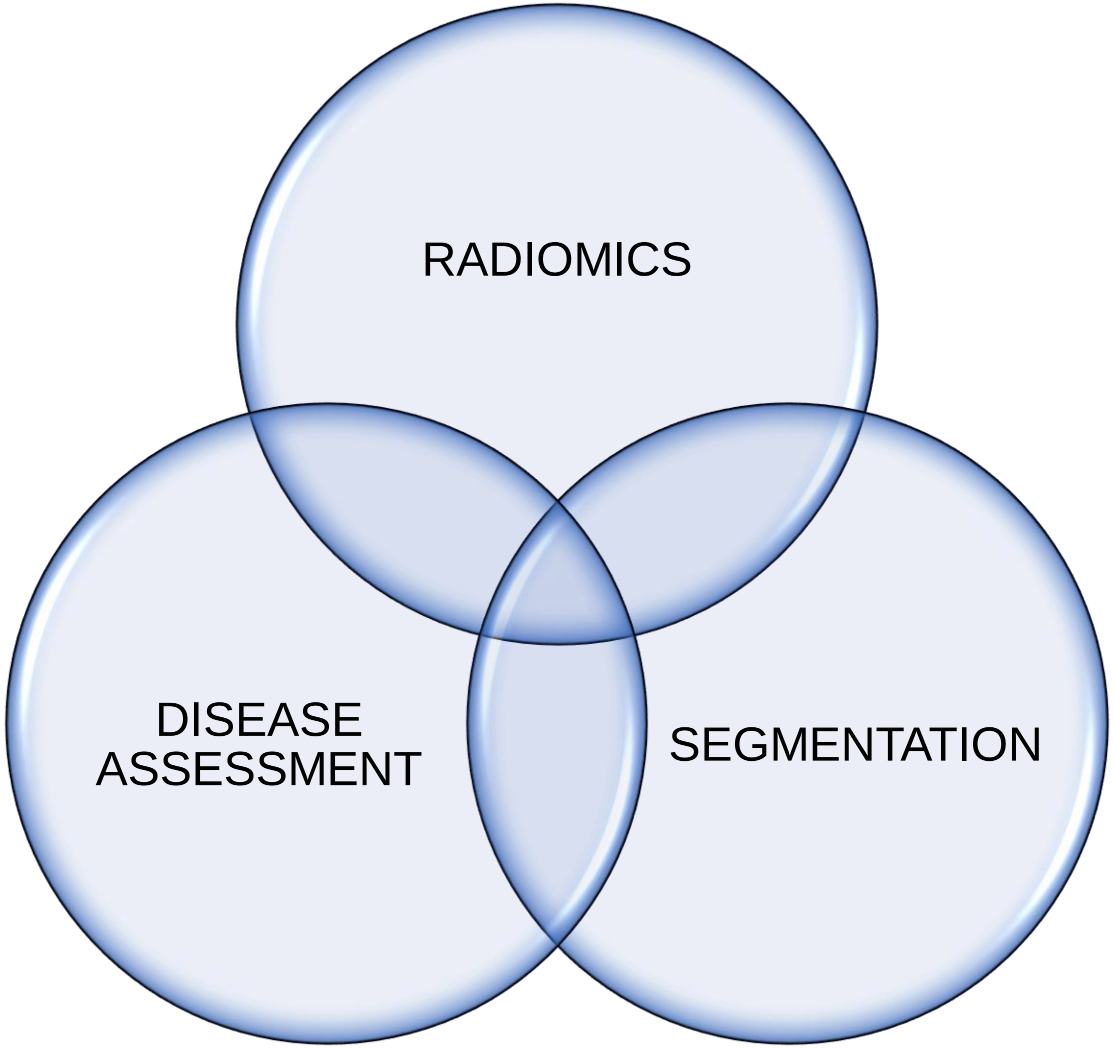
PET
CT
RM



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2020

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6. Comelli, A.; Bignardi, S.; **Stefano, A.**; Russo, G.; Sabini, M. G.; Ippolito, M.; Yezzi, A. Development of a New Fully Three-Dimensional Methodology for Tumours **Delineation** in Functional Images. *Comput. Biol. Med.* 2020, *120*, 103701.
7. Comelli, A.; **Stefano, A.**; Bignardi, S.; Coronnello, C.; Russo, G.; Sabini, M. G.; Ippolito, M.; Yezzi, A. *Tissue Classification to Support Local Active* **Delineation** *of Brain Tumors*; Annual Conference on Medical Image Understanding and Analysis, 2020; Vol. 1065 CCIS.
8. Comelli, A.; **Stefano, A.** *A Fully Automated **Segmentation** System of Positron Emission Tomography Studies*; Annual Conference on Medical Image Understanding and Analysis, 2020; Vol. 1065 CCIS.
9. Palmucci, S.; Torrisi, S. E.; Falsaperla, D.; **Stefano, A.**; Torcitto, A. G.; Russo, G.; Pavone, M.; Vancheri, A.; Mauro, L. A.; Grassedonio, E.; et al. **Assessment** of Lung Cancer Development in Idiopathic Pulmonary Fibrosis Patients Using Quantitative High-Resolution Computed Tomography: A Retrospective Analysis. *J. Thorac. Imaging* 2020, *35* (2), 115–122.

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2020

1. Alongi P; **Stefano, A.**; et al. 18F-Choline PET/CT **Radiomics** to predict survival outcome in high risk prostate cancer: an explorative study on machine-learning feature classification in 94 patients .

2. Comelli, A.; et al. Hybrid descriptive-inferential method for key feature selection in prostate cancer **Radiomics**

3. **Stefano, A.**; Diagnostic performance of standard qualitative and **Radiomics** approach to parotid gland tumors: which is the added benefit of texture analysis?

4. Comelli, A.; et al. *Deep Learning for prostate* ***segmentation*** *to obtain reproducible results in radiomics studies*

5. Comelli, A.; et al. *Lung* ***segmentation*** *on high-resolution computerized tomography images using* **deep learning***: a preliminary step for radiomics studies*

6. Comelli, A.; et al. *Deep Learning Approach for the* ***segmentation*** *of Aneurysmal Ascending Aorta*

7. **Stefano, A.**; et al. Smart and Innovative **Monitoring** Response to Therapy Strategy in Patients with Brain Lesions

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Georgia Institute of Technology

National Research Council of Italy

Facoltà Dipartimentale di Ingegneria

Seminario

Image Processing for Medical Decision Support System

Human eyes are not always able to detect and interpret complex patterns in bio-medical images. Considering the need to make rapid clinical decisions, quantitative methods to analyze bio-images are mandatory in clinical environment.

Two approaches in terms of High-Resolution Computed Tomography (HRCT) and Positron Emission Tomography (PET) image analysis will be presented:

- Radiomics in idiopathic pulmonary fibrosis and lung cancer
- A smart and operator independent system to delineate tumors in PET studies

These approaches are used as a Medical Decision Support System to enhance the current daily methodology performed by healthcare operators.

Dott. Albert Comelli. Born in 1981, he is a PhD Student in Computer Engineering at the University of Palermo and Research Affiliate at the Laboratory of Computational Computer Vision (LCCV) in the School of Electrical and Computer Engineering at Georgia Institute of Technology, Atlanta, Georgia, USA. He received the Combined BSc's/MSc's Degree in Computer Science in 2013 (University of Catania). His research interests include medical image processing and medical data analysis. Author of 9 publications in peer-reviewed journals and international conference proceedings.

Ing. Alessandro Stefano. Born in 1980, he is a Research Scientist with the Institute of Molecular Bioimaging and Physiology, National Research Council (IBFM-CNR), Cefalù. He received the Laurea degree (summa cum laude) and the Ph.D. in computer engineering in 2005 and 2016, respectively. His research interests include medical image processing.
Author of more than 20 publications in peer-reviewed journals and international conference proceedings.

Prof. Anthony Yezzi holds the position of Julian Hightower Chair Professor within the School of Electrical and Computer Engineering at Georgia Institute of Technology where he directs the Laboratory for Computational Computer Vision. He has over twenty years of research experience in shape optimization via geometric partial differential equations. He has consulted for a number of companies including GE, 3M, MZA, Philips, Picker, and VTI.

Martedì, 12 giugno 2018 - ore 14:00
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Computers in Biology and Medicine 102 (2018) 1–15

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Computers in Biology and Medicine

journal homepage: www.elsevier.com/locate/compbiomed

A smart and operator independent system to delineate tumours in Positron Emission Tomography scans

Albert Comelli[a,b,c], Alessandro Stefano[a,*], Giorgio Russo[a,d], Maria Gabriella Sabini[d], Massimo Ippolito...

Engineering Applications of Artificial Intelligence 81 (2019) 133–144

Contents lists available at ScienceDirect

Engineering Applications of Artificial Intelligence

journal homepage: www.elsevier.com/locate/engappai

K-nearest neighbor driving active contours to delineate biological tumor volumes

Albert Comelli[a,b,c], Alessandro Stefano[b,*], Giorgio Russo[b,d], Samuel Bignardi[a], Maria Gabriella Sabini[d], Gi...

Artificial Intelligence In Medicine 94 (2019) xxx–xxx

Contents lists available at ScienceDirect

Artificial Intelligence In Medicine

journal homepage: www.elsevier.com/locate/artmed

Active contour algorithm with discriminant analysis for delineating tumors in positron emission tomography

Albert Comelli[a,b,c], Alessandro Stefano[b,*], Samuel Bignardi[a], Giorgio Russo[b,d], Maria Gabriella Sabini[d], ...

Computers in Biology and Medicine 120 (2020) 103701

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Development of a new fully three-dimensional methodology for tumours delineation in functional images

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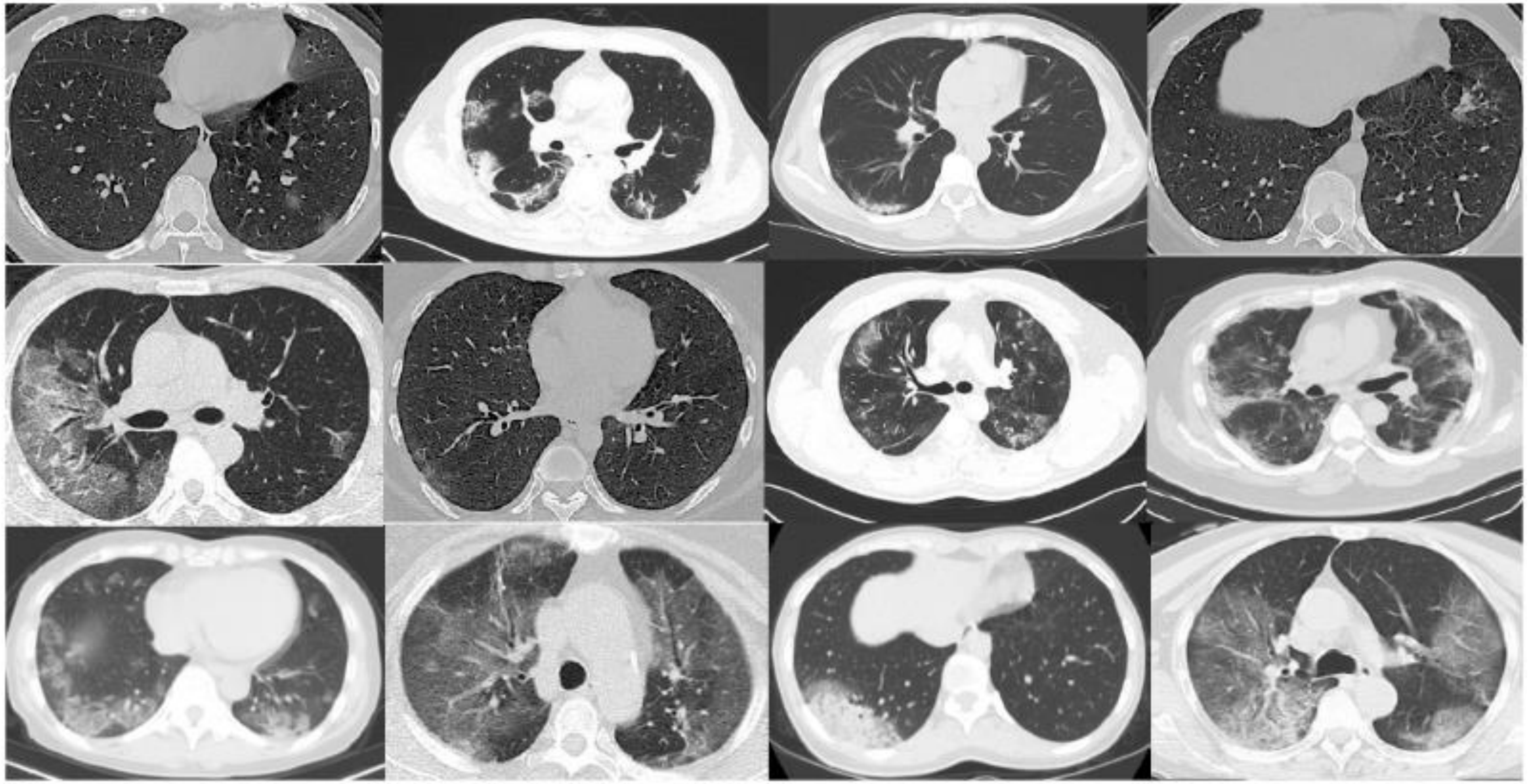
diagnostics — MDPI

1 Article
2 Performance of Radiomics Features in the
3 Quantification of Idiopathic Pulmonary Fibrosis
4 from HRCT

5 Alessandro Stefano[1], Mauro Gioè[2], Giorgio Russo[1*], Stefano Palmucci[3],
6 Sebastiano Emanuele Torrisi[4], Samuel Bignardi[5], Antonio Basile[3], Albert
7 Comelli[6,1], Viviana Benfante[1], Gianluca Sambataro[3,7], Daniele Falsaperla[3],
8 Alfredo Gaetano Torcitto[3], Massimo Attanasio[2], Anthony Yezzi[5] and Carlo
9 Vancheri[4]

Georgia Tech

Examples of CT scans that are positive for COVID-19.



Xingyi Yang, Xuehai He, Jinyu Zhao, Yichen Zhang, Shanghang Zhang, Pengtao Xie
COVID-CT-Dataset: A CT Scan Dataset about COVID-19. arXiv:2003.13865

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Article

Performance of Radiomics Features in the Quantification of Idiopathic Pulmonary Fibrosis from HRCT

Alessandro Stefano[1], Mauro Gioè[2], Giorgio Russo[1*], Stefano Palmucci[3], Sebastiano Emanuele Torrisi[4], Samuel Bignardi[5], Antonio Basile[3], Albert Comelli[6,1], Viviana Benfante[1], Gianluca Sambataro[3,7], Daniele Falsaperla[3], Alfredo Gaetano Torcitto[3], Massimo Attanasio[2], Anthony Yezzi[5] and Carlo Vancheri[4]

ORIGINAL ARTICLE

Assessment of Lung Cancer Development in Idiopathic Pulmonary Fibrosis Patients Using Quantitative High-Resolution Computed Tomography

A Retrospective Analysis

Stefano Palmucci, MD, Sebastiano E. Torrisi, MD,† Daniele Falsaperla, MD,* Alessandro Stefano, PhD,‡ Alfredo G. Torcitto, MD,* Giorgio Russo, MD,‡ Mauro Pavone, MD,† Ada Vancheri, MD,† Letizia A. Mauro, MD,* Emanuele Grassedonia, MD,§ Gianluca Sambataro, MD,†‖ Silvia Puglisi, MD,¶ Sara Piciucchi, MD,# Sara Tomassetti, MD,¶ Venerino Poletti, MD,** Antonio Basile, MD,* and Carlo Vancheri, MD, PhD†*

Torrisi et al. Multidisciplinary Respiratory Medicine (2018) 13:43
https://doi.org/10.1186/s40248-018-0155-2

Multidisciplinary Respiratory Medicine

ORIGINAL RESEARCH ARTICLE Open Access

Assessment of survival in patients with idiopathic pulmonary fibrosis using quantitative HRCT indexes

Sebastiano Emanuele Torrisi[1*†], Stefano Palmucci[2†], Alessandro Stefano[3], Giorgio Russo[3], Alfredo Gaetano Torcitto[2], Daniele Falsaperla[2], Mauro Gioè[4], Mauro Pavone[1], Ada Vancheri[1], Gianluca Sambataro[1,5], Domenico Sambataro[5], Letizia Antonella Mauro[2], Emanuele Grassedonio[6], Antonio Basile[2] and Carlo Vancheri[1]

Albert Comelli, Claudia Coronnello, Giorgio Russo, Navdeep Dahiya, Viviana Benfante, Stefano Palmucci, Antonio Basile, Carlo Vancheri, Anthony Yezzi, and Alessandro Stefano.

Lung segmentation on high-resolution computerized tomography images using deep learning: a preliminary step for radiomics studies

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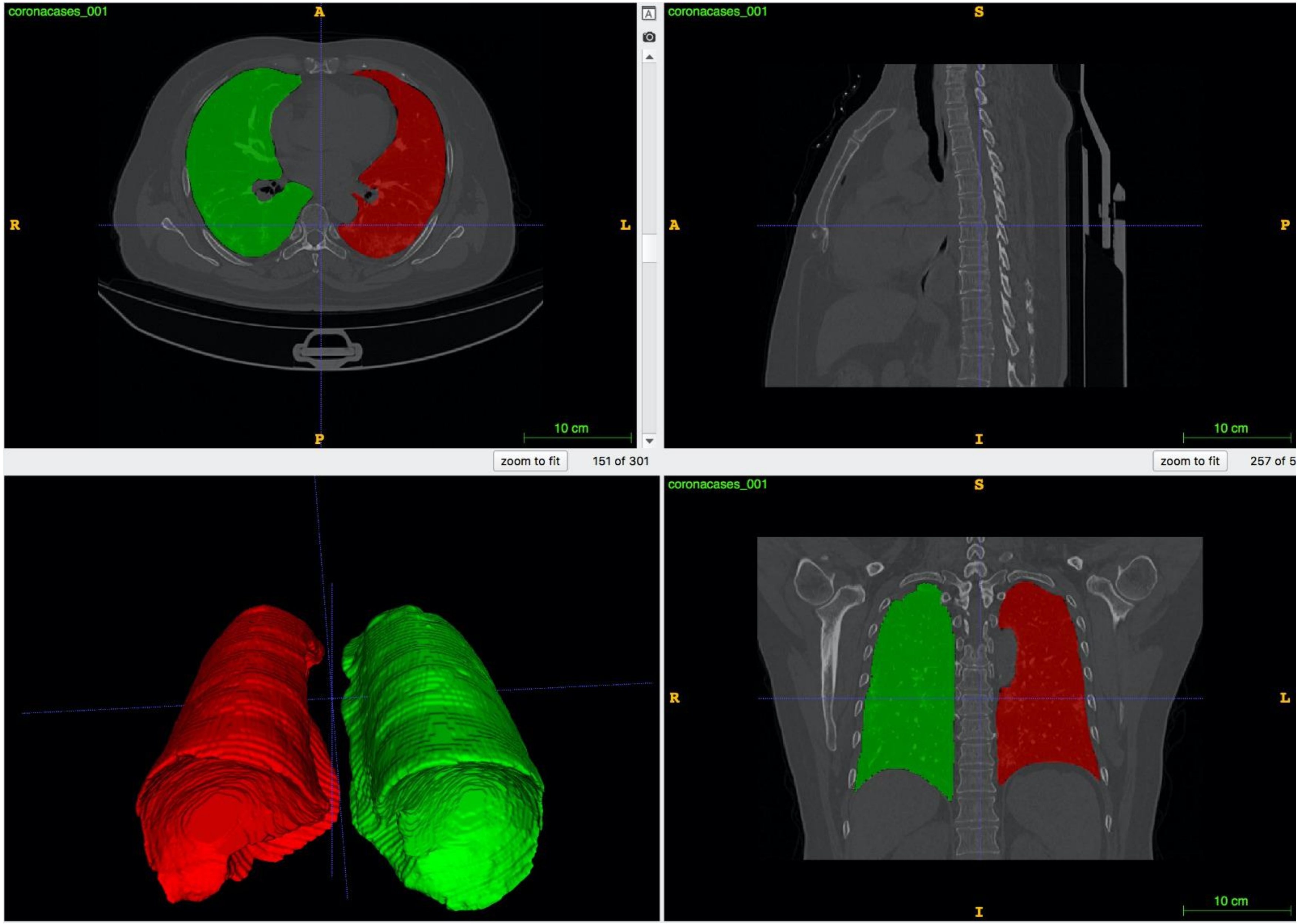
COVID-19 : Unsupervised Lung Segmentation for Radiomics Studies



We use an innovative and fast deep learning algorithm whose purpose is to tackle the real-time, three-dimensional, fully automated segmentation task of HRCT datasets.

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COVID-19 : Unsupervised Lung Segmentation for Radiomics Studies

After automatic segmentation, we extract radiomics features and we use a novel feature selection approach to identify a relevant prognostic model to differentiate between patients with COVID-19 and other lung diseases (fibrosis, pneumonia, cancer, etc).

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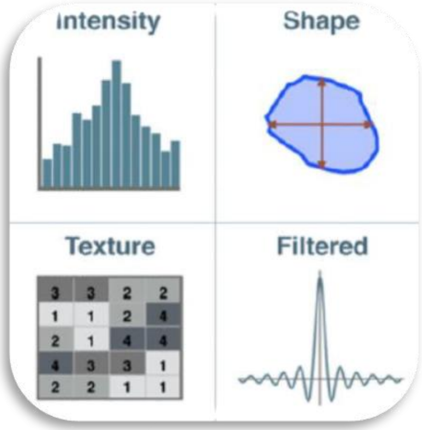
Radiomics in HRCT

I. HRCT imaging

II. Lung delineation

III. Features



IV. Model Building

Classifiers able to assign label or to predict the autcome:

- Neural Networks
- Support Vector Machines
- Quantum-inspired Min Distance Classification
- Etc..

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From IPF to.... COVID-19

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The features of IPF are fibrotic regions and honeycombing.

IPF and COVID-19 can share radiological features, namely ground glass opacities and consolidation, but they are not defining IPF features.

Both COVID-19 and IPF may result in inflammation, even so the typical characteristics on CT between COVID-19 and IPF are not the same.

So, a neural network trained exclusively on IPF data will almost certainly not perform well on COVID-19 cases, especially those with diffuse consolidation.

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Albert Comelli, Claudia Coronnello, Giorgio Russo, Navdeep Dahiya, Viviana Benfante, Stefano Palmucci, Antonio Basile, Carlo Vancheri, Anthony Yezzi, and Alessandro Stefano.

Lung segmentation on high-resolution computerized tomography images using deep learning: a preliminary step for radiomics studies

A retrospective analysis of interstitial lung disease (Policlinico-Vittorio Emanuele Hospital of Catania)

Patients with an unenhanced, supine, volumetric thin-section CT exam (no more than 1.25 mm)

42 IPF patients

The majority of patients in our study were male (age > 50 years).

Two different CT scanner:

- 11 studies obtained using the CT Philips scanner have a matrix resolution of 720 x 720
- 31 studies obtained using the CT GE scanner have a matrix resolution of 672 x 672.

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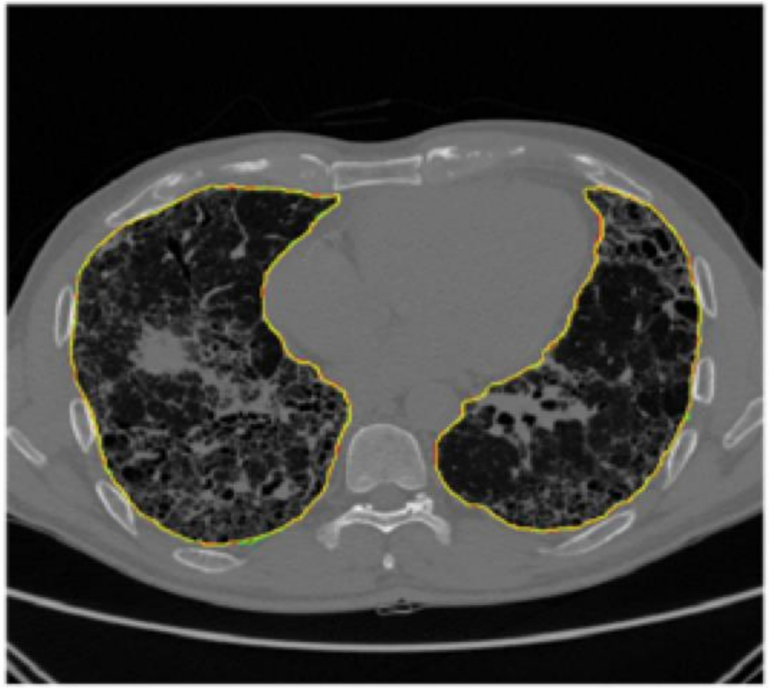
Lung segmentation on high-resolution computerized tomography images using deep learning: a preliminary step for radiomics studies

First, we resampled all datasets to isotropic voxel size with the same matrix resolution.

To overcome imbalanced data and limited amount of available labelled data issues, we:

- *implemented ad-hoc pre-processing process based on the loss function*
- *applied a suitable data augmentation technique*
- *adapted the original three different Deep learning Methods*
- *used the k-fold strategy.*



- *DSC ~ 96%*

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Lung segmentation on high-resolution computerized tomography images using deep learning: a preliminary step for radiomics studies

(b)

- *When computations are performed on CPUs, the proposed DL takes less than 2 minutes, while U-NET takes more than 23 minutes.*
- *Using GPU, 20s versus 46s .*

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As a matter of fact, DL approaches, such as radiomics studies, are very sensitive to different image features as reconstruction kernels, resolution, image quality, etc.

We have tried the segmentation of a public dataset with very different image features (https://wiki.cancerimagingarchive.net; CT Siemens Biograph 40 scanner with a thin-section of 3 mm. In our study, the section is $<$ 1.25 mm being HRCTs) obtaining poor results.

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The next step... COVID-19

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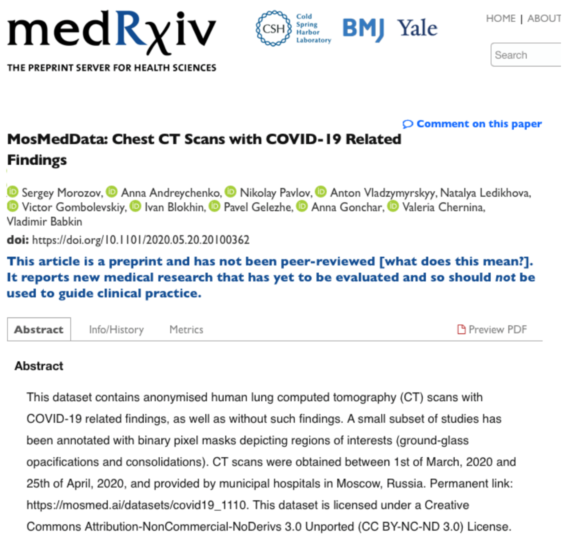
MosMedData: COVID19_1000 Dataset

This dataset contains anonymised human lung CTscans with COVID-19 related findings, as well as without such findings provided by medical hospitals in Moscow, Russia.

A small subset of studies (50) has been annotated with binary pixel masks depicting regions of interests (ground-glass opacifications and consolidations).

CT-0 (/studies/CT-0 directory): normal lung tissue, no CT-signs of viral pneumonia.
CT-1 (/studies/CT-1 directory): several ground-glass opacifications, involvement of lung parenchyma is less than 25%.
CT-2 (/studies/CT-2 directory): ground-glass opacifications, involvement of lung parenchyma is between 25 and 50%.
CT-3 (/studies/CT-3 directory): ground-glass opacifications and regions of consolidation, involvement of lung parenchyma is between 50 and 75%.
CT-4 (/studies/CT-4 directory): diffuse ground-glass opacifications and consolidation as well as reticular changes in lungs. Involvement of lung parenchyma exceeds 75%.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MosMedData: Chest CT Scans with COVID-19 Related Findings

Sergey Morozov, Anna Andreychenko, Nikolay Pavlov, Anton Vladzymyrskyy, Natalya Ledikhova, Victor Gombolevskiy, Ivan Blokhin, Pavel Gelezhe, Anna Gonchar, Valeria Chernina, Vladimir Babkin

doi: https://doi.org/10.1101/2020.05.20.20100362

This article is a preprint and has not been peer-reviewed [what does this mean?]. It reports new medical research that has yet to be evaluated and so should *not* be used to guide clinical practice.

Abstract | Info/History | Metrics | Preview PDF

Abstract

This dataset contains anonymised human lung computed tomography (CT) scans with COVID-19 related findings, as well as without such findings. A small subset of studies has been annotated with binary pixel masks depicting regions of interests (ground-glass opacifications and consolidations). CT scans were obtained between 1st of March, 2020 and 25th of April, 2020, and provided by municipal hospitals in Moscow, Russia. Permanent link: https://mosmed.ai/datasets/covid19_1110. This dataset is licensed under a Creative Commons Attribution-NonCommercial-NoDerivs 3.0 Unported (CC BY-NC-ND 3.0) License.

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Work in progress…